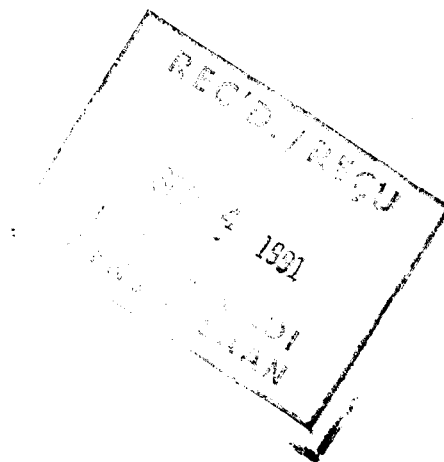
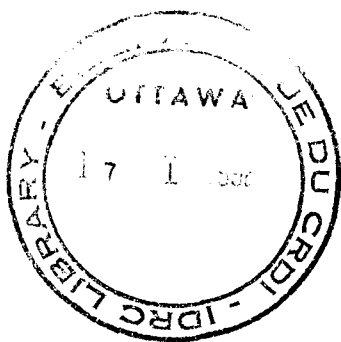


HERBIVORES IN ASIA

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ABSTRACT

Efficiency in the use of the herbivore resources in Asia is discussed in the context of their diversity, extent of current use and potential contribution. The reference to herbivores includes various ruminants and equines, both indigenous and introduced. Among these, cattle have received overwhelming research and development attention, in comparison to buffaloes, goats and sheep. Camels and equines have received little or no attention and resource support. Increased contribution from herbivores requires more concerted development based on clear objectives of production, and their potential importance in sustainable systems that are closely identified with more efficient and intensive use of the feed resources. Prevailing ruminant production systems are unlikely to change in the foreseeable future since such changes would need to be supported by large resource inputs. However, shifts within the systems are likely due to intensification, increased demand for animal products, consumer preferences, marketing opportunities, sustainability and environmental integrity. Particular emphasis therefore needs to be given in Asia to the application of the results of feeding and nutrition experiments and rural-oriented developing strategies that can give priority to more efficient use of available feeds on-farm. The elements of extending information on fibrous crop residues to on-farm situations, including criteria for such activities, are considered in two phases : 1) The information needed by farmers and their advisers, and 2) Mechanisms for delivering information to farmers. Increasing the contribution from herbivores requires more balance development of these resources based on priorities, relevance to agriculture, and national needs.

INTRODUCTION

Herbivores in Asia are extremely important animal genetic resources. This importance is associated with two primary reasons. Firstly, there is considerable diversity in the types of available animals. Secondly, and associated with the first reason, is the varied contribution that these animals make in the different agro-ecological zones in Asia.

The herbivores constitute both native and introduced genotypes and are very widely distributed across a variety of climates and agro-ecological environments. In these situations their contribution to agriculture is

formidable, but not completely understood in terms of their specific functions, and contribution to farming systems. In these circumstances, an enquiry into the extent of their use, and nutritional characteristics in the context of their current contribution and potential increased productivity is therefore appropriate. The latter is also justified by the need for strategies that can fully utilise the available herbivores so as to maximise the contribution of meat, milk and draught. For purposes of this paper, Asia is defined to include all countries east of and including, Pakistan, Indo-China, the Association of South East Asian nations (ASEAN) and the South Pacific.

THE CLIMATIC ENVIRONMENT

The distribution of major climate zones of the world indicates that Asia would be classified as tropical. The reference to tropical designates the area between the Tropics of Cancer and Capricorn, and a large proportion of the Asian bioclimate falls within this same area (Figure 1). The climate fall under the classification of equatorial, arid, montane and tundra proposed by (1). However, many microclimates exist within this zone due to the interaction of several climatic variables which produce specific climates in individual locations. These variables include latitude, altitude, soils and topography, distribution of land and water, winds, rainfall and vegetation.

In view of the presence of several micro-climates, it is appropriate to consider the major climatic diversions in Asia. These include the following:

- (i) The equatorial high humidity region
- (ii) Humid sub-tropical
- (iii) Semi-arid and arid
- (iv) Warm temperate sub-tropical, and
- (v) Montane

The equatorial climate is found from 5 to 7° latitude north and south of the equator and is characterised by a constant level of heat, high annual rainfall (5000-5500 mm) and high humidity. Rainfall is abundant, and although roughly distributed throughout the year, tends to be heavy during some parts of the year and lighter at other times. In general, animals within this climate tend to be smaller in size due to the effects of humidity and possess low growth. South India, Bangladesh, Indo-China and all countries in South East Asia and the South Pacific will fall into this category.

The equatorial high humidity region, together with the high rainfall, favours vigorous plant growth. Forage production is relatively easy and

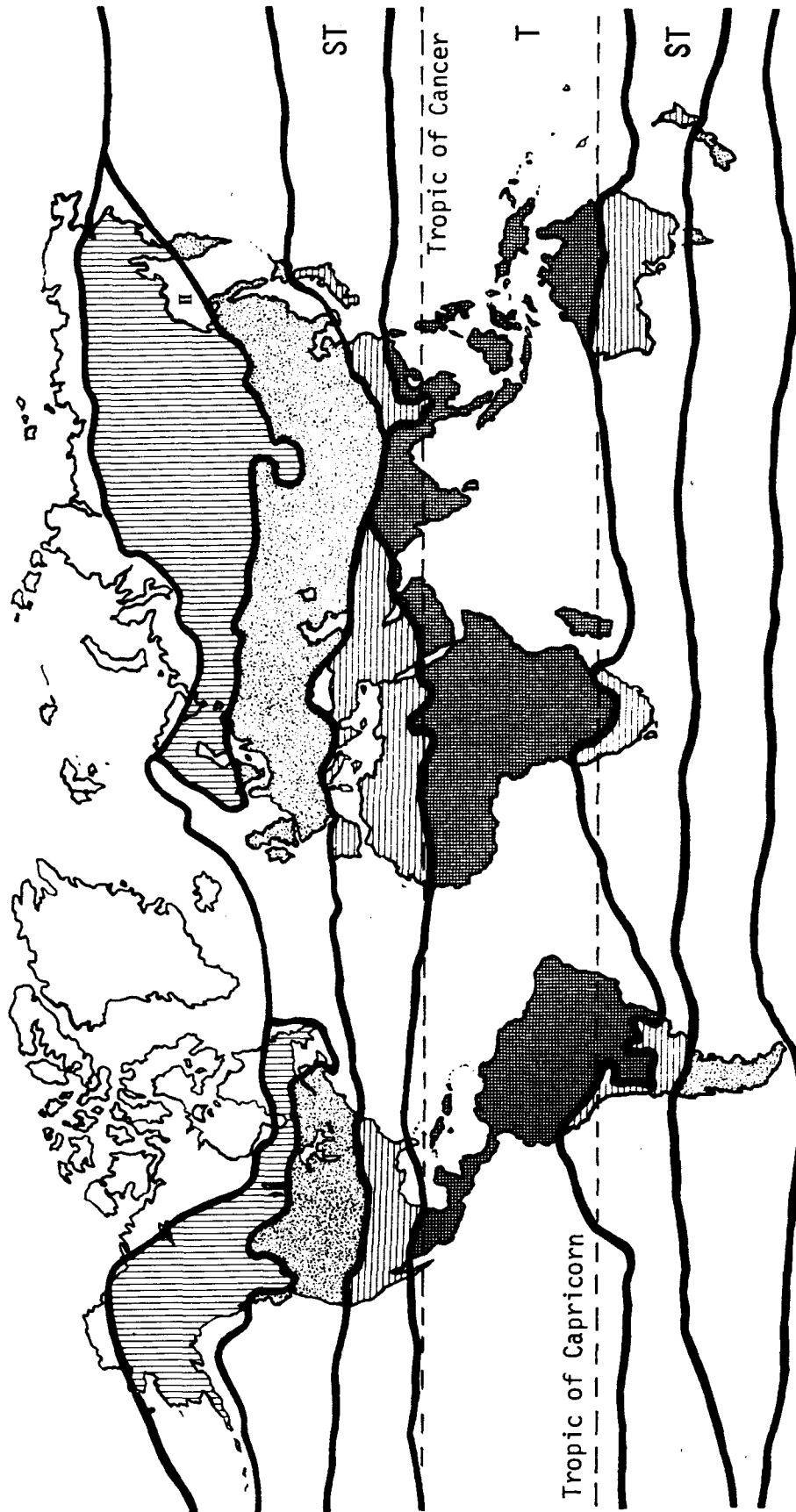


Fig. 1. The tropical climates of the world comprise essentially the area within the tropics (T) and the warm-temperate sub-tropical regions (ST).

available all the year round. The main problem however is one of control of growth to ensure that the forages are not mature, too fibrous and have good nutritive value when fed to animals. Associated with intensive crop production is the presence of abundant fibrous crop residues which are potentially important to the nutrition of herbivores. Additionally, and with specific reference to tree or perennial crops like coconuts, oil palm and rubber, there exists considerable native undergrowth and an abundance of shade which is advantageous especially for introduced exotic animals into this zone. One serious disadvantage of this climate is that the high humidity and rainfall that this climate provides, favours internal and external parasites, which if uncontrolled can be a major constraint to animal production.

The warm temperate sub-tropical region has high seasonal temperatures, humidity and rainfall. The total rainfall of about 1200-1500 mm is less than that in the equatorial zone. Three seasons are distinct: cool-dry, hot-dry and hot-wet. The climate is common adjacent to the equatorial areas, and unlike the equatorial zone, there are fewer months of heat stress. Many parts of south and central China would fall within this zone.

The semi-arid and arid regions have relatively low annual rainfall (200-450 mm) and humidity, and long dry seasons. Temperature fluctuations are very wide, both diurnal and seasonal, and the intensity of solar radiation is high. West and northern parts of Pakistan, India, Mongolia and the northern parts of Australia all fall under this climate. Transhumant and nomadic systems of animal production are common in the Indian sub-continent and Mongolia, and the livelihood of the farmers in these parts is often associated entirely with the ownership of animals. In India for example, as many as 55 million poor people live in this zone and whose livelihood is associated mainly with the ownership and/or management of goats and sheep.

The montane region constitutes those areas varying in altitude between 305-1524 m. A very large portion of the highlands of Asia falls within this zone. These high altitude highlands, with focus on the Hindu Kush-Himalayan region, are an area of extreme contrast and diversity. The region consists of mountains, hills and plateaus of Afghanistan, Bangladesh, Bhutan, Myanmar, China, India, Nepal and Pakistan. The elevations range between 150 to 8880 m and the average altitude exceeds 4000m for the entire range (2). Most of the animal activities occur in the middle hill and high mountain region up to 2500 m.

The range as a whole is characterised by the complexity of climate, vegetation, human and animal components and their interactions. This complexity manifests in differences in farming systems appropriate to the different ecological zones and the density of human populations in these parts. Both the complexity of the systems, as well as the sparse base

of knowledge on the management of the available resources has called for increased attention on the development of this region, including the more effective use of the ruminant resources which can be identified with their current importance and future potential.

The agro-climatic environments in the Asian region with reference to the semi-arid, arid and humid tropics, are unique in that these present contrasting extremes of the effects of climatic components and therefore differential responses in animals. These bio-climates range from tropical desert characterized by temperature extremes (0° - 52°C), insignificant rainfall and sparse vegetation, to the wet tropics with high temperature, humidity and rainfall (3000-5500 mm), and abundant vegetative cover. In both situations, ruminants play an important role in agriculture and render valuable service to man. Examples range from nomads with their camels, goats and sheep practicing shifting agriculture in the arid regions of the northern Indian sub-continent, to small farmers rearing water buffaloes (*Bubalus bubalis*) and cattle in complex crop-livestock systems in monsoonal Asia. In this region, meat, milk and draught power are vital contributions made by these species.

The agro-ecological conditions are also the main determinants of crop and livestock systems that develop in any one situation. Ruminant production systems are particularly dependent on vegetation, and arable and perennial cropping for their feed base. The feed component is especially relevant as it is the primary link between crops and animals. The interaction between crops and animals provides for important socio-economic factors which are advantageous to farm households and landless peasants; it also provides stability to farming systems.

MAN AND HIS ANIMALS

The Asian and Far East region, including China, has about one-half of the world's human population, but less than one-fifth of the agricultural area. This region also has two-thirds of the world's poorest people, predominantly of small farmers, tenants and landless agricultural labourers. In many countries, about 69-91% of the population are rural poor, and both rural and urban poverty are reflected in high infant mortality rates and inadequate access to safe water.

Zebu cattle, goats and sheep all originated in West Asia. Two main routes of dispersion from western Asia are thought to have been used from as early as 2000 BC: the 'silk road' through Afghanistan to Mongolia or north China and the route to the Indian sub-continent through the Khyber pass. Figure 2 illustrates the postulated dispersion route of domestic goats from the domestication area to East, South and South East Asia, which also involved other ruminants. These migratory routes involved nomads and several types of people and included not only these

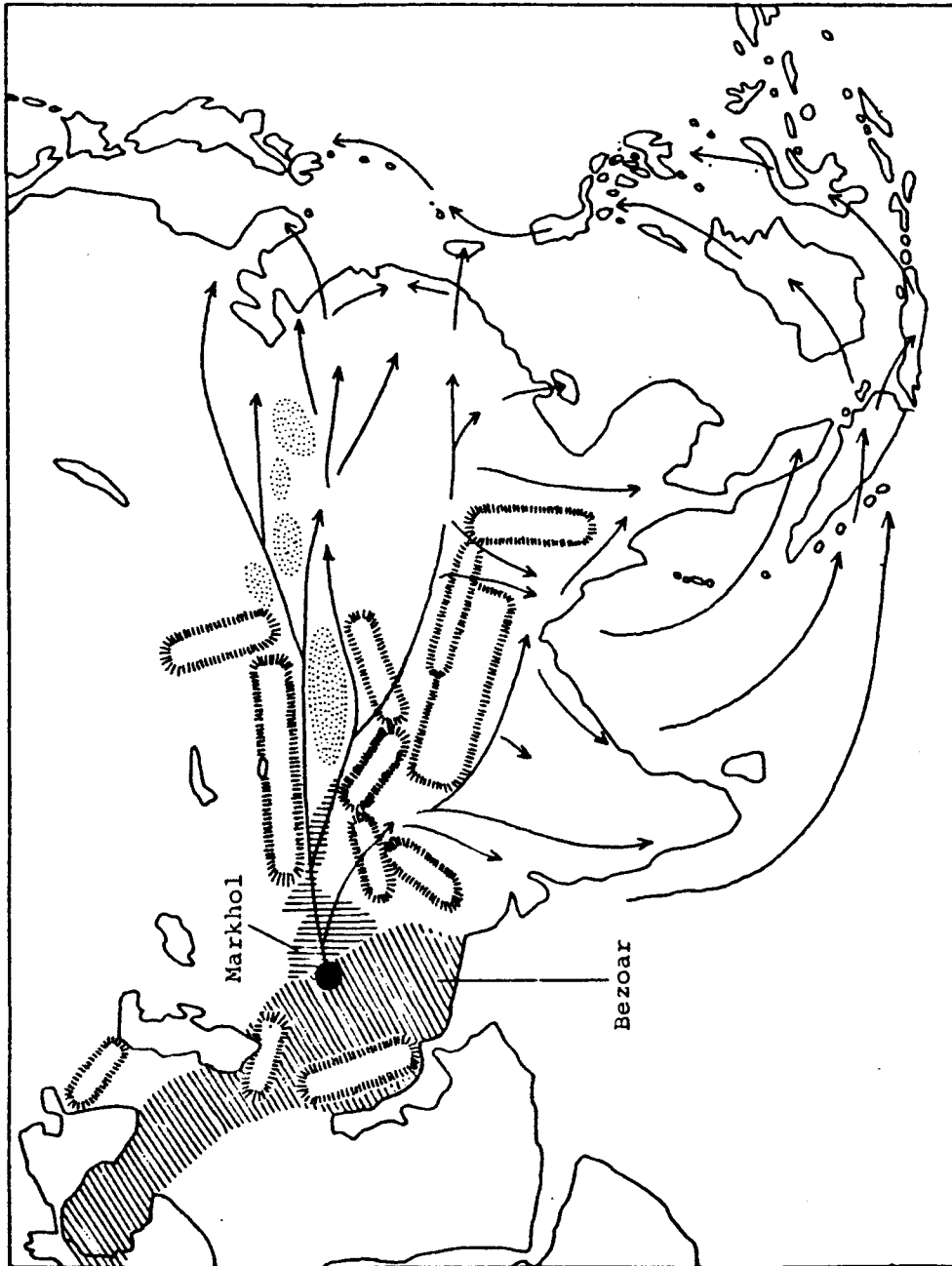


Fig. 2. Postulated dispersion route of domestic goats from domestication area (closed circle) to East and South East Asia (3).

animal species but also dromedaries. Buffaloes are believed to have been derived from the Bubalus arnee, the wild buffalo of mainland Asia. In the Philippines, there also exists in the island of Mindoro the tamaraw (Bubalus mindorensis); however it has 46 chromosomes, compared to the swamp with 48 and the river 50 chromosomes.

Buffaloes and cattle are more suited to the equatorial climate and their value is also identified with crop cultivation in which small mixed farm systems combining crops and animals form the backbone of agriculture in Asia. Introduced animals are also mainly found in this zone and small farmers who practice mixed farming, grow mainly cereals and cash crops as well as rear animals (ruminants and non-ruminants). Crops and animals together make an important economic contribution and also provide stability to the farming systems.

The semi-arid and arid regions favour the presence of goats, sheep and camels. Feed and water are critical constraints to animal production, which cause severe stress in animals. Both external and internal parasites are also found here but are not as great as in the humid zone.

In respect of camels, the genus Camelus has two species, the one-humped camel or dromedary found in Africa, West Asia, Pakistan and India, and the two-humped camel or Bactrian found in Mongolia and western parts of China. A useful book on camels and their management (4) with reference to India, and an annotated bibliography on the one-humped camel have recently been published (5).

In the complex Hindu Kush-Himalaya region, ruminants are thriving resources within the farming systems, fully adapted to the area and serve a variety of important functions. These include buffaloes, cattle, goats, sheep, donkeys, yak and chauri.

The effective utilisation of the herbivores is mainly influenced by the agro-climatic environment, since adaptation, ability to thrive in different situations, and extent of expression of the genetic potential of animals are dependent on the interaction of the climatic components, mainly temperature, radiation, humidity and rainfall (6).

THE PRODUCTION RESOURCES

I. HERBIVORE RESOURCES

(i) Population size and distribution

Table 1 summarises the types and magnitude of the herbivore resources in Asia. It is important to keep in perspective the different types of herbivores available, the population size relative to total world population, and the annual growth rate specific to each species.

Among domestic ruminants, 98% of buffaloes, 57% of goats, 30% of cattle and 28% of sheep, in terms of total world population are found in Asia. In addition, there also exist between 24-51% of the total world population of asses, camels, horses and mules.

TABLE 1
HERBIVORE RESOURCES IN ASIA(7)

Species	Population (10 ⁶)	Percentage of total world population (%)	Annual rate of growth 1979-1989 (%)
Buffaloes	137.7	98.0	1.2
Cattle	855.0	30.4	1.5
Goats	463.2	56.8	1.5
Sheep	601.2	28.3	1.8
Asses	38.8	50.5	3.7
Camels	17.2	23.9	0.8
Horses	42.6	26.2	-ve
Mules	14.7	38.2	2.9

Among the herbivores, the domestic ruminants (buffaloes, cattle, goats and sheep) have received most attention. By comparison, asses, camels, horses and mules have received little or no attention. Curiously, despite the ownership and importance of the latter species, very little support has been given to these to increase their role and contribution to farming systems. Thus for example, although the value of camels in the supply of draught power in semi-arid and arid environments such as in northern Pakistan and India is widely recognised, national research programs have consistently not addressed research and development of these species in order to maximise the contribution from the totality of the herbivore resources.

India now has a Bureau of Animal Genetic Resources and also Research Centres for Camels in Bikaner and Equines in Hisar. Limited work has been initiated and is being reported (see for example 8 and 9).

The Asian region also has other species within the genus Bos. These include the yak (Bos mutes) of the Central Asian Highlands, the wild Banteng (Bos javanicus) which is domesticated in Bali and Bos frontalis. The mithan is believed to be derived from the wild gaur, and the two are fully compatible genetically. The mithan is widely reared by the hill tribes of Assam, Bhutan, Sikkim and Myanmar (10) and although not used for draught or milk, is valued for meat after ceremonial sacrifice. Both the Banteng and the mithan originated within Asia.

In the highlands of central Asia, the yak is a thriving animal at altitudes above 3000 metres, where the temperature is below freezing for eight months of the year. Yak are valued for meat and milk, fibre, skins

and haulage. Yak and cattle can breed and the female hybrids called chauri are fertile but males are not (11). The yak is also an important animal in the highlands of China (12).

The herbivore resources include a variety of indigenous and also introduced animals. In South Asia, there exist about 28 well defined breeds of cattle, but uncontrolled breeding is apparent. Additionally various exotic cattle breeds for both dairy and beef production have been widely introduced, followed to a lesser extent by sheep and goat breeds, simply because of the emphasis given to cattle production. Among the dairy breeds the use of the Holstein-Friesian breed has been widespread followed by the Jersey. Among the beef breeds introduced, the Shorthorn, Brahman, Hereford and Charolais are the most common.

In most countries within the Asian region, dairy development is accorded the highest priority in livestock development programmes. Indeed, in all countries without exception, dairy development forms the main thrust in animal production. There are several reasons for this which inter alia include, demand for milk and milk products, means of generating ready income for small farmers, efficiency of protein and energy conversion, entry point to stimulate rural development, means to effectively use family labour, development of cooperatives, alleviation of the level of human nutrition and quality of the life of the rural poor, and means of intensifying crop-animal systems in small farms.

With small ruminants, the Asian region has approximately 62 potentially important breeds. A variety of exotic sheep breeds have been introduced into the region mainly from the United Kingdom and Australia. They include the Merino, Dorset Horn, Romney, Wiltshire Horn, Border Leicester, Suffolk and Polled Dorset. The predominant goat breeds that have been introduced include the Alpine, Saanen, Anglo-Nubian, Toggenburg and German Fawn. Although these various breeds have been introduced, and several crossbreeding programmes have been initiated in general, examples of stabilised crossbred and proven improved new breeds are very few, but one recent achievement concerns the evolution of two genotypes in Malaysia based on long-term crossbreeding of the indigenous Katjang type animals with the German Fawn (13). The two crossbred are the Jermana (50% German Fawn X 50% Katjang) and the Jermasia (75% German Fawn X 25% Katjang). Another example of a stabilised crossbred is the Xinong goat in the Shaanxi Province in China, which has resulted from crossing native goats with Saanen goats from Canada in the 1940's (14).

(ii) Adaptation characteristics

Table 2 summarises the more important characteristics of ruminants and equines. Exploiting potential productivity in these resources necessitates that these characteristics and individual biological attributes, especially that of feeding and metabolism are recognised.

Table 2

ADAPTATION OF RUMINANTS AND EQUINES (15)

Species	Arid/semi-arid zone	Wet zone
Buffaloes (<u>Bubalus bubalis</u>)		Larger size (400-600 kg) Stocky Low hair density Limited sweat glands (140-150 cm ²) Light to dark colour Grey skin to reduce solar and radiant heat Very indented epidermis Strong pigmentation
Cattle (<u>Bos indicus</u>)	Taller Large size (350-450kg) Loose skin and appendages Able to walk long distance	Shorter, compact body Medium size (300-500 kg) Thicker skin Higher hair density Sparse pigmentation More sweat glands (800-1500 cm ²)
Goats (<u>Capra hircus</u>)	Large size (30-50 kg) Tall (70-100 cm ht) Long legs and ears Soft spongy hooves White, black or brown colour, shiny skin Short hair covering Prehensile lips Fat reserves less than sheep (mainly visceral) Survivability greater than sheep	Small size Short (50-65 cm ht) Short legs and small ears Mainly black or brown coat Less shiny skin ♦
Sheep (<u>Ovis aries</u>)	Large size (30-50 kg) Tall (60-80 cm ht at withers) Long legs Thick hooves Cream to brown colour Fibre covering High fat reserves	Small size (10-25 kg) Short legs and small ears Coarse wool, more matted

The domestic ruminants are generally owned by small farmers, peasants and landless labourers. They are distributed across all agro-ecological

environments, but are predominantly found in mixed small farms in which they make an important contribution to sustainable agricultural systems.

In view of the priority on the development of domestic ruminants in most countries in Asia, this objective should also be expanded to include the other herbivore animals.

Water buffaloes in the humid tropics are particularly well adapted to take advantage of the high rainfall and high humidity. The skin thickness is about two to three times greater than that of cattle, is indented, heavily pigmented and provides protection from radiation. An adaptational factor in water buffaloes is the relatively small number of sweat glands ($140-150/\text{cm}^2$ vs $800-1500/\text{cm}^2$ in cattle). These glands show a tendency to atrophy which further limits the water buffaloes' capacity to lose heat; it is not clear when the glands atrophy but this characteristic contributes to their relatively low heat tolerance compared with cattle. When exposed to direct sunlight, water buffaloes significantly increase their rectal temperature, respiratory rate and heart rate (15, 16, 17). Nevertheless, water buffaloes are capable of activity in open sunlight and in situations where there are no wallows. In these situations, they attempt to dig holes to remain cool. Their capacity to work in open sunlight is probably related to a decline in metabolic heat production during prolonged exposure to heat (19).

Zebu cattle (*Bos indicus*) in Bangladesh fed with untreated rice straw have been reported to have a significantly greater rumen and total gut contents than those given urea-treated rice straw. Expressed as a percentage of live weight, both groups gut contents and tissues are far greater than European cattle (*Bos taurus*) (6). This could be genetic or due to adaptation, but is an advantage to these animals in utilising coarse roughages.

Goats in arid regions absorb low amounts of solar radiation, can withstand dehydration and show greater capacity for survival in this environment than do sheep. In the humid tropics, the Black Bengal goat in Bangladesh, India and Pakistan is very common with low adult live weights of about 9-13 kg. Elsewhere in South East Asia, the Katjang goats are relatively small with adults weighing about 18-20 kg live weight. The precise reason for dwarfism is not known, but it has been suggested that this is an adaptation to poor nutrition and a low metabolic rate (20).

Camels in the arid regions are distinctively one-humped, which together with the long neck and legs enable adaptation to a very harsh environment. In addition, the camel has long eye lashes and nostrils that are almost closed to protect it against the sand in the desert. The animal is valued for draught and milk production. Strong baggage camel in Pakistan can carry a load of approximately 800 kg (21).

(iii) Contribution by herbivores

Table 3 summarises the trends in per caput supply of animal products in Asia between 1977 and 1988. Increased production is apparent for all commodities, especially in regard to mutton and lamb and eggs. With respect to goat meat, beef and veal and buffalo meat, the increases were small. Mutton and lamb supply increased considerably in 1988, probably due to increased imports. Significant increases in the supply of both buffalo and cow milks were apparently made and this suggests good progress made in dairy production in Asia. The supply of chicken eggs more than doubled over the same period.

Table 3

PER CAPUT SUPPLY OF ANIMAL PRODUCTS IN ASIA (22,23)
(g/day)

Commodity	1977	1988	Increase/yr (%)
Beef and veal	0.29	0.33	1.1
Buffalo meat	0.42	0.62	4.0
Goat meat	0.18	0.22	1.9
Mutton and lamb	0.07	0.29	26.2
Buffalo milk	7.80	8.50	0.8
Goat milk	0.44	0.58	2.7
Cow milk	7.70	9.82	2.3
Eggs	337.3	679.6	8.5

Of the components of the animal industries in Asia, dairy development has had a major impact on rural development in several countries. This impact has been particularly significant in those countries such as in South Asia where there is a long tradition for dairying and milk consumption. It has been effectively used as an entry point for rural development in these same countries. The success of this is illustrated by the progress that has been made in India through "Operation Flood" aims at developing producer cooperatives, the union of village cooperatives and the federation of unions. The programme has been particularly successful in milk collection, processing and distribution

and has now been in operation for the past 20 years. Today, about 170 major milk sheds and about 55,000 cooperatives are involved in providing services for a membership in excess of about 5.5 million farmers. More than anything else, dairy development has been outstandingly successful in promoting social and economic change especially among the landless and rural poor in India.

One important output which is not reflected in Table 3 concerns draught animal power. Unfortunately, limited statistics are available on the contribution that herbivores make in providing draught animal power. Buffaloes, cattle, asses, camels, horses and mules are widely used throughout the developing countries for draught purposes, ranging from a variety of ploughing and transportation operations. However, limited quantitative data is available on the contribution that draught animals make and the effects these have on crop production. Likewise the effect of possible increases in the availability of draught power and use within farming systems is not known.

In India, it is estimated that 80 million draught animals make available 40 million horse power throughout the land, including two-thirds of the land cultivated of about 100 million hectares. The savings in the equivalent use of fuel is considerable and replacement of draught animal power with petroleum-based power is impractical and unrealistic to resource-poor farmers who are illiterate and have no access to credit. On average, the draught animals are used for about 100 days annually. The strategy for research and development is how to increase the power output per animal as well as the number of days of use of these animals for crop production and other haulage operations.

The FAO (24) study on agricultural projections has estimated that the power inputs in developing countries would have to increase by 2.3% per annum to achieve an overall agricultural growth rate of 3.4% per annum by the year 2000. This would involve an overall increase of 15% in the number of draught animals and an increase of 400% in tractor numbers. The latter would involve expenditure of considerable capital which would not be readily available. Greater reliance on draught animals for crop cultivation involving buffaloes and cattle, and haulage operations using camels and equines would therefore be necessary. It is therefore possible that draught animals and their contribution to a variety of uses in agriculture can play a much more important role in the future provided there is more support for research and development on them.

II. FEED RESOURCES

The feed resources refer to the availability from the totality of permanent pastures, forest and woodlands, crop residues, agro-industrial by-products and non-conventional feeds.

(i) Permanent pastures, forest and woodlands

Table 4 sets out the extent of permanent pastures available and also land under forests and woodlands. Also given in the table is the corresponding magnitude of the ruminant livestock units available, based on calculations from FAO data. Of particular significance is the marked imbalance between the total ruminant livestock units and available permanent pastures in Asia compared to the other regions. It is in this region, to include centrally planned economies, more than any other, that there exists acute feed shortages to meet the requirements of ruminants, such that continuing low per animal performance is more the rule rather than the exception. The importance of making maximum use of all available feed resources thus assumes far greater importance, and is a particularly important strategy in this situation.

Table 4

**EXTENT AND DISTRIBUTION OF PERMANENT PASTURES, FORESTS
AND WOODLANDS AND RUMINANT LIVESTOCK (25)**

Region	Permanent pastures (10 ⁶ ha)+	Forest and woodlands (10 ³ ha)+	Ruminant livestock units (10 ⁶)++
Developing market economies			
Africa	631.2	645.7	138.4
Asia and the Far East	109.8	220.5	356.3
Latin America	512.7	928.8	253.2
Near East	267.6	95.2	67.0
Total	1521.3	1890.2	814.9
Asian centrally planned economies	409.8	188.6	100.5
Total developing countries	1931.1	2078.8	915.4
World total	3170.8	4086.6	1319.6
As % of world total	60.9	50.9	69.4

+ Refer to 1975 data

++ Conversion Factors: Buffalo 1.0, Cattle 0.8,
Goats and Sheep 0.1

The forest and woodlands have also been included in the table to provide a reminder about the potential importance of the herbage available under these perennial tree crops, including also the use of some of the more important leaves. These feed resources have not been adequately utilised in the past for want of adequate methodology to facilitate the process of integration, involving appropriate choice of species, objectives of production that can ensure high productivity from the land due to the combined thrust of both animal and crop association. In South, South East and the Pacific Islands for example, there exists about 20×10^6 ha under tree crops. Even if only half of this crop area is utilised by animals, the number of animal equivalents that can be carried, and productivity from them, assumes considerable magnitude (26,27).

(ii) Crop residues, agro-industrial by-products and non-conventional feeds

In addition to feeds from pastures, ruminants in the developing countries depend on three other categories: crop residues, agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR).

Crop residues are mainly fibrous materials that are by-products of crop cultivation. Due to the intensity of and emphasis on crop production in Asia, these form a high percentage of the total volume of the feeds produced annually. They generally have a low crude protein content, in the range 3.3-13.3% on a dry matter basis. This suggests a basic limitation in the value of some of the residues (e.g. bagasse and rice straw) around the border line of the 6-7% dietary crude protein level required for promoting voluntary matter intake. Most of the residues are also deficient in fermentable energy, reflected by the relatively low organic matter digestibility.

Agro-industrial by-products refer to the by-products derived in the industry due to processing of the main products. They are, in comparison to crop residues, less fibrous and more concentrated, and have a higher nutrient content. Good examples of AIBP are molasses, rice bran, pineapple waste, palm oil mill effluent (POME) produced from refining the palm oil, and coconut cake.

Non-conventional feed resources (NCFR) are identified separately although they can be components of both crop residues and AIBP. NCFR refer to all those feeds that have not normally been used in commercially produced rations for livestock. Whereas the traditional feeds of crop origin tend to be mainly from annual crops, the NCFR include commonly, a variety of feeds from perennial crops and feeds of animal and industrial origin. Examples of NCFR are oil palm by-products, single-cell proteins, feed materials of plant and animal origin (e.g. poultry excreta), and poor-quality cellulosic roughages from farm residues such as stubbles, haulms and vines.

Table 5 summarises the availability of NCFR in Asia and the Pacific. From field, plantation and tree crops alone, the total availability is approximately 513 million tonnes. Of this, about 238×10^6 tonnes or 46% are considered to be NCFR. This total availability is higher than the figure suggests, as it does not include calculations of feeds derived especially from animal slaughter and the food processing industries.

Table 5

**THE AVAILABILITY OF NON-CONVENTIONAL FEED
RESOURCES IN ASIA AND THE PACIFIC (28)**

Category	Availability (10^6 t)
Field crops	230.3
Tree crops	7.4
Total	237.7 ⁺

+ Represents 46.3% of the total availability from field and plantation crops.

The very high animal densities in Asia and inadequate land for grazing is exacerbated by chronic annual feed shortages throughout South Asia notably Pakistan, India and Bangladesh despite attempts to use as much of the available feeds as is possible. In these countries, feed deficits and the malady of undernutrition was a continuing problem, but good progress is being made towards reducing feed deficits despite increased animal populations over the decade.

The improvements are a reflection of improved feeding systems, more efficient use of the available feeds, and increasingly intensive systems of production. Whether in terms of scale and magnitude, these approaches are adequate and can be further improved is a matter of debate. It has recently been pointed out (29) that many NCFR remain to be more widely used in India, implying that there is still scope for reducing the feed deficits.

RUMINANT PRODUCTION SYSTEMS

The prevailing ruminant production systems in Asia are of three categories as follows :

- i) Extensive systems
- ii) Systems combining arable cropping
 - Roadside, communal and arable grazing systems
 - Tethering
 - Cut-and-carry feeding
- iii) Systems integrated with tree cropping

Taking cognisance of the prevailing patterns in the use of the production resources, growing animal populations and available grazing land, it has been suggested that future trends in ruminant production systems in South and South East Asia and the South Pacific are unlikely to change (30). The changes are unlikely as they would need to be supported by large resource inputs, access to which would be difficult unless the economic returns from the proposed new systems were demonstrably superior. The principal strategy should therefore be maximum use of indigenous feed resources (31).

However, more efficient use of the production resources and the objective of increasing per animal performance will bring about shifts within the systems through intensification, from the more extensive to systems combining arable cropping and integration with tree cropping systems will occur. The poorest of the resource-poor farmers and especially the landless will obviously continue practicing extensive systems, but strategies need to promote intensive systems that reduce grazing pressure, provide for control animal numbers and promote sustainability and environmental integrity. Factors which are likely to influence this process in the future include:

- o Increasing density of animal populations
- o Control of grazing ruminants
- o Available feed resources
- o Growth in human populations and demand for animal products
- o Consumer preferences and marketing opportunities, and
- o Sustainability and environmental integrity

APPLICATION OF FEEDING AND NUTRITION RESULTS

Since the focus of attention in this international symposium is the nutrition of herbivores, it is appropriate to discuss the more applied aspects of the subject. This is also justified by several other concerns which inter alia includes:

- o Feeding and nutrition is the main constraint to animal production
- o Very high animal densities, decreasing grazing land, decreasing feed resources, and need for more control and intensification.
- o Overgrazing, environmental degradation and increasing rangelands. In India, this accounts for about 158 million hectares and about 1.5 million ha are lost annually to deforestation (32).
- o Prevailing ruminant production systems (extensive systems, systems combining arable cropping, and systems integrated with tree cropping) that are unlikely to change.
- o Need to increase the efficiency of protein production from ruminants to match the increasing demand from rising human populations.

Given these primary considerations, and doubts about the efficiency of food production from ruminants, it is imperative that there is greater application of information concerned with feeding and nutrition across all herbivores. In particular, it is especially essential to extend and apply information already available on feedstuffs, a subject area which Asia more than any other region has made significant advances in. A good deal of accumulated information exists on the utilisation of feedstuffs in Asia. However, most of this is locked in the experiment and university station levels. Numerous meetings have been held and the extent and frequency of these is indicated in Table 6. These do not include the annual meetings that are held on the subject through the Indian Council of Agricultural Research (ICAR) supported All India Coordinated Research Project on the Utilisation of Agricultural By-products and Industrial Waste Materials for Evolving Economic Rations for Livestock and other national meetings.

Table 6
**MEETINGS ON FEEDS
 AND FEEDING SYSTEMS IN ASIA (1977-1990)**

Country	Year
Bangladesh	1981, 1982, 1983
India	1986, 1987, 1988a, 1988b, 1988c, 1990
Indonesia	1981, 1984, 1985, 1987
Japan	1983, 1990
Malaysia	1977, 1986, 1987
Pakistan	1983
Philippines	1980, 1983, 1987, 1989
Sri Lanka	1984, 1986
Thailand	1984, 1985, 1988

In Asia, over the period 1977 to 1990, there have been a total of 28 regional meetings, equivalent to about two meetings annually. The results and information presented in all these meetings are generally sound and have significantly contributed to fundamental knowledge. Yet, these have not made any discernable impact on more intensive and expanded utilisation of the available feeds. This observation is reflected further in the conclusion on the review of research on the utilisation of rice straw (33). The authors concluded that the importance of evaluating new technologies through on-farm testing and demonstrations far out-weighed the need for further documentation of the effects of supplementation or pretreatments.

The relevance of the work done is particularly critical for ruminants (buffaloes, cattle, goats and sheep), and is more depressing compared with non-ruminant (pigs and poultry) industries. The latter have made major increases in production through the application of advanced technology to improved breeds fed mainly on imported energy and protein concentrates.

ON-FARM APPLICATION OF FEEDSTUFFS INFORMATION

The application of feedstuffs information and the accumulated knowledge on feeding and nutrition merits therefore the highest priority to increase productivity of meat, milk and draught in animals. On-farm animal research (OFAR) is probably the only accurate assessment of whether new technology packages are acceptable both economically and socially to the farmers as they take into account all the interacting components unique to farming systems. They are a means of identifying and addressing the constraints to adoption of new feeding systems, and the extent to which they contribute to sustainability (34). Two phases are involved :

Phase I : Information needed by farmers and their advisers

1. Choice of feeds and their availability over seasons.
2. Nutritive value : detailed information on constituents, prediction of changes during periods of production, capacity to meet production target, and capability of filling any nutritional gap.
3. Strategic supplementation : On animal performances and on sustained production of the basal feed resources.
4. Feeding system.
5. Level and type of production (meat, milk and/or draught).
6. Realistic production target.

Phase II : Mechanisms for delivering information to farmers

7. Methodology : balance between fundamental and applied research.
8. Linkages across disciplines and institutions.
9. Demonstration of economic benefit.
10. Large scale on-farm testing.
11. In situ utilisation.
12. Farmer participation
13. Definition of a model for feed resource development.

Intensification of feed resource use is implicit, and with it, a shift from the more extensive to semi-intensive and intensive systems. Presently, small farmers, agricultural labourers and agricultural tenants raise small ruminants mainly in extensive systems. The poorest of these resource-poor farmers and especially the landless will obviously continue practicing these systems, but the long term sustainability of these grazing systems is questionable. The strategy to promote semi-intensive and intensive feeding systems which the project addresses would reduce prevailing grazing pressures. The more progressive of the poor farmers are willing to adopt improved systems which can provide greater control of animals and higher incomes, provided the benefit can be demonstrated in on-farm testing in sustainable production systems.

CRITERIA FOR DEVELOPMENT ORIENTATION

Increased and more concerted development orientation concerning the utilisation of feedstuffs and feeding and nutrition of herbivores, also requires attention to several important criteria for on-farm activities. These include inter alia the following : objectives of production, the treatments involved, the precise methodologies to be used to support the work, the measurements to be undertaken, type and value of the inputs used and the outputs derived from the experiment, extent of farmer participation, issues related to the economic analysis of the results, and marketing.

It is envisaged (35) that by the turn of this century, there will be little suitable land for increasing the area of arable crops. The quantity of crop residues will therefore remain static, and if the production of meat, milk and draught power are to be maximised, more intensive systems of production and increasingly higher per animal output is essential. The study further emphasises that advances can only be achieved with the availability of technologies, diffusion of knowledge and application, in which on-farm experimentation was crucial. These issues further emphasise the need to focus thoroughly on the choice of feeds, relevance of the technology development and application at the farm level. With fibrous crop residues, largescale intensive utilisation on-farm merits the highest priority to increase the current level of contribution by animals.

Associated with this development is the measurement of impact. Research and development programmes need to address the beneficial value of the derived technology with reference to such criteria as value added; real benefits to small farmers, peasants and landless labourers; income generation; pollution control, and possible expansion in animal production activities. The latter refers to more intensive use of the totality of the animal resources to include not only ruminants (buffaloes, cattle, goats and sheep) and non-ruminants (pigs, chickens and ducks), but also other herbivores like the camels and the donkeys.

STRATEGY FOR MORE EFFICIENT USE OF HERBIVORES

In consideration of the rising individual herbivore populations, pressure on land use, environmental concerns and need for maximising productivity from animals, it is important to consider the implications of not addressing these problems in the future. Central to this is the potential future use and importance of these animals in the context of efficient use of the available resources. Failure to address this is associated with poor definition of priorities in the use of individual herbivores, promotion of further inefficiencies concerning productivity from them, and possibly also damage to the environment.

The elements of this strategy include choice of species, breeds within species, control of numbers and use of available feed resources that are consistent with objectives of production and national priorities. The importance of such planning and the need for strategies is exemplified by the situation in India where there is intense pressure on land use by animals and chronic annual feed deficits. The calculations refer to four ruminants and focus essentially on the energy requirements for maintenance for 1977 and 1988, and projections for the year 2000 using the recommendations for goats in NRC (36), and also those of (37) for cattle and buffaloes (Table 7).

Table 7

CURRENT AND PROJECTED METABOLISABLE ENERGY REQUIREMENTS OF RUMINANTS AND AVAILABILITY IN INDIA (38)

Species	ME Requirements (10^9 MJ)		
	1970	1988	2000
Goats and sheep ⁺	0.67	1.02	1.39
Buffaloes ⁺⁺ and cattle ⁺⁺	3973.9	4480.7	5341.2
Total ruminants	3974.6	4481.7	5342.6
Requirements as % of availability	-26.2	-25.5	-34.4

- + The daily requirement is $6.52 \text{ MJ/W}^{0.75 \text{ kg}}$
- ++ The daily requirement is $56.1 \text{ MJ/W}^{0.75 \text{ kg}}$
- +++ The daily requirement is $42.7 \text{ MJ/W}^{0.75 \text{ kg}}$

When these calculations are also related to the requirements by the other ruminants (buffaloes, cattle and sheep), and the available feed resources, the annual metabolisable energy (ME) requirements are in excess by between 26 and 34%. The deficits are underestimated as they do not include the energy requirements of non-ruminants and other herbivores such as camels, donkeys, mules and asses.

These calculations clearly emphasise the need for definite strategies that allow for more efficient use of the feed resources by individual ruminants relative to functions, control over numbers, and increased use of chosen breeds within species. Control of animal numbers especially in the Indian sub-continent is clearly important, but is unlikely to be achieved in practice. Maximising high production from animals must therefore favour strategies that give greater attention to "improved" animals and more intensive systems of management in controlled situations.

CONCLUSIONS

Herbivores in Asia are characterised by diversity and are distributed across all environments, from semi-arid, arid, humid regions and to the highlands. The diversity is reflected not only by the presence of several indigenous breeds within domestic ruminants, but also by camels and equines and a variety of introduced breeds over time. Within the ruminant animals, cattle development has received priority, followed by buffaloes, goats and sheep. Camels and equines have unfortunately received little or no attention. Increased productivity from them requires more balanced development of the herbivore resources based on priorities and national needs, and particularly, more efficient use of both the animal feed resources. The overriding issue, and one which merits the highest priority, is application of the available information based on the advances that have been made on the principles of feeding and nutrition. Associated with these approaches, more intensive and sustainable systems of production are necessary to ensure higher levels of productivity from animals to meet increasing consumer demands and preferences, control of animal numbers and maintenance of environmental integrity. These issues need to be more vigorously addressed and targetted to herbivores in general, and domestic ruminants in particular, in real farm situations throughout Asia.

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